Observations

5G Is Coming: How Worried Should We Be about the Health Risks?

So far, at least, there's little evidence of danger

- By Kenneth R. Foster on September 16, 2019

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Judging from the enthusiastic reception of 5G technology by governments and industry, we are on the verge of a technological revolution. Initially introduced to help wireless networks cope with ever-increasing data traffic on their networks, 5G will (its proponents claim) lead to game-changing innovations such as remote surgery, control of driverless vehicles and much more.

5G, eventually slated to replace present-day 3G and 4G cellular telephone networks, promises to speed up the rate of data transfer by 100 times or more, greatly reduce latency (time between receipt of a signal by a cellular base station and its response) and allow cellular networks to manage far more wireless-connected devices than presently possible.

5G, however, has become intensely controversial in many locations, with citizens' groups, and a few scientists, expressing concerns about the possible health effects of radio-frequency (RF) energy transmitted by 5G base stations. Public opposition appears to focus on two characteristics of 5G networks:

First, 5G systems will operate in several frequency bands, including one that is slightly below (and will eventually extend into) the millimeter-wave part of the RF spectrum that extends from 30 to 300 GHz. While millimeter waves have not heretofore been used for cellular communications, they have been used for many other applications, including airport security scanners, anticollision radar for automobiles, and to link present-day cellular base stations.

Public discussions appear to conflate 5G with millimeter-wave communication. In fact, many 5G networks will operate at frequencies close to those used by present cellular networks, and some may use millimeter waves to handle high data traffic where needed.

Second, 5G systems will rely on a multitude of "small cells" mounted close to subscribers, often on utility poles running along public streets. These small cells will incorporate "smart" antennas that transmit multiple beams (up to 64 with present designs, eventually more), which can be independently steered to individual subscribers. They operate at much lower power levels than "macro" cells used by present systems, which are typically located on tops of buildings in urban areas.

In the long run, these will be supplemented by pico cells that are mounted inside buildings, operating at still lower power levels. The prospects of a

dramatic increase in the number of sources transmitting RF signals is undoubtedly disquieting to many citizens, regardless of the actual health risks as understood by health agencies.

The U.S. Federal Communications Commission (FCC) has made the introduction of 5G a high priority, paring back some regulations and giving local communities less control over the placement of small cells (although the issue has been in litigation and this may change somewhat). Thus, communities are facing the introduction of new infrastructure incorporating what is, to the public, new and unfamiliar technology. Engineers, for their own part, are inclined to regard 5G as an extension of present (3G, 4G) cellular technology.

The possibility of harms from environmental exposures to radio-frequency signals has been a long-standing concern of many citizens, leading to public opposition to wireless base stations, broadcasting facilities, cell phones and other commonplace technologies. In a 2017 survey of 2,450 residents of six European countries, Peter Wiedemann, then at the University of Wollongong in Australia, found that 40 percent of the respondents had some concerns, with 12 percent describing themselves as "enduringly concerned"—that is, frequently thinking and talking about electromagnetic field exposure.

Their concerns chiefly focused on "involuntary" exposures to RF signals from environmental sources, including cellular base stations. Activist groups, supported by an echo chamber of Internet Web sites, have protested the installation of Wi-Fi in schools, wireless-enabled electric utility meters, cellular base stations, and other infrastructure that transmits RF energy into the environment.

While levels of public exposure to RF fields from future 5G networks have not been surveyed in detail (few such networks are in operation and the technology is evolving rapidly) it seems unlikely that they will be very different than those from existing cellular networks because the fundamental imperatives of the technology are the same: to provide a signal that is strong enough to communicate with an individual subscriber but not strong enough to cause interference to users in adjoining cells.

Even now, cellular networks are undergoing "densification" (adding many small cells) to manage their ever-increasing data traffic. By allowing faster transmission of data and steering beams toward individual users, 5G may, in fact, work to reduce the overall levels of RF signals in the environment—but that will eventually be offset by the rapidly growing data traffic on cellular networks and by the eventual flood of wireless-connected devices that 5G will make possible.

A 2019 review of environmental levels of RF signals, however, did not find an increase in overall levels since 2012 despite the rapid increase in use of wireless communications, in part because of "improvements in efficiency of these technologies and improved power controls of all emitters."

Beginning in the 1960s many studies have examined possible biological and health effects of RF exposure, and several thousand papers on the topic now exist (see Figure 1). Initially, these studies were motivated by occupational health concerns for workers exposed on the job to high levels of RF energy from industrial heating and other equipment. More recently many studies have been undertaken to examine potential health risks from environmental exposures from communications systems. There has recently been an upsurge of research using millimeter waves, although none at the precise (and, for the most part, still undetermined) frequencies to be used by 5G systems.

Millimeter waves are absorbed within about 0.5 mm of the skin surface, unlike RF energy at lower frequencies that can penetrate deeper into tissue. Its obvious potential hazards—thermal damage to skin or cornea of the eye—have been examined by numerous studies including many sponsored by the U.S. Air Force beginning in the mid-1990s (the present author participated in several of these) and also studies on ocular effects of millimeter waves by a group at Kanazawa Medical University in Japan. One of these studies was a long-term cancer promotion study on mice, involving periodic exposures to intense pulses of millimeter waves, that found no effects of exposure; the study has unclear relevance to communications signals however.

Apart from a relatively few studies that are directly relevant to safety, the literature contains a great many studies looking for biological effects of millimeter waves pursuing endpoints that cannot be related directly to possible health risks. Most of these studies reported some kind of biological effects of exposure. They vary widely, however, in approach, endpoint,

exposure characteristics, and quality. Many of these studies are exploratory in nature, and lack elementary precautions to ensure reliable results.

Most countries around the world have adopted RF exposure limits that are roughly similar to present FCC limits. FCC and similar limits are designed to avoid established hazards of RF energy that result from excessive heating of tissue. A few countries (for instance Italy, Belgium and India) and cities (such as Paris) have adopted lower limits on "precautionary" grounds (roughly described by the rubric "better safe than sorry").

These are, in part, a political accommodation to concerned citizens, and in part a hedge against the possibility that low level or "nonthermal" hazards might be demonstrated in the future. Russia and some of its former Warsaw Pact allies also have much lower exposure limits, an inheritance from the old Soviet Union.

This confusion has been present for many years, but there has been little change in the assessments by health agencies. In its 2018 review, the Swedish Radiation Safety Authority concluded that "despite the lack of established mechanism[s] for affecting health with weak radio wave exposure there is however need for more research covering the novel frequency domains, used for 5G." In August 2019, FCC Chairman Ajit Pai announced that the commission proposes to maintain its current RF exposure safety standards (adopted in 1996), quoting a statement from the Director of the U.S. Food and Drug Administration Center for Devices and Radiological Health that "[t]he available scientific evidence to date does not support adverse health effects in humans due to exposures at or under the current limits."

In contrast to the cautious and generally reassuring assessments by health agencies, a few scientists have warned loudly about possible hazards of 5G. Martin Pall, a retired professor of biochemistry at Washington State University, is the most visible scientist in the public arena on this issue. In numerous public presentations and in his online book on 5G, Pall has made a number of sensational claims—for example that 5G will cause an "almost instantaneous" crash in human reproduction "almost to zero."

Other groups, particularly in Europe, have pressed for a moratorium on rollout of 5G. An appeal, signed by245 scientists as of August 2019, recommended "a moratorium on the roll-out of the fifth generation, 5G, for

telecommunication until potential hazards for human health and the environment have been fully investigated." In a response to the appeal, in late 2017, Vytenis Andriukaitis (head of the Cabinet of Commissioners of the European Union) reiterated reassuring advice of expert reports and indicated that the request to "stop the distribution of 5G products appears too drastic a measure. We first need to see how this new technology will be applied and how the scientific evidence will evolve." He indicated that the commissioners would keep abreast of future developments.

To "fully investigate" potential hazards of 5G (or any other technology) is an open-ended program without a clear stopping point. With cellular communications systems there is a potentially unlimited number of exposure parameters (frequency, modulation, intensity) to be explored. (In contrast, absorbed power, which determines temperature increase in tissue, is much easier to quantify.) Moreover, "5G" refers to a set of specifications for operation of a cellular network, not to any particular source or frequency of exposure. Many initial rollouts of 5G networks, in fact, transmit frequencies at power levels that are similar to those of present cellular networks.

Apart from Martin Pall and a relatively few additional scientists, health agencies have not concluded that exposure to RF fields at ordinary environmental levels carries any health risks. Given this situation, Andriukaitis' response seems reasonable: see how the science develops. If a clear rationale develops for changing exposure limits, governments and the communications industry will have to adapt.

Because of the scattered literature on bioeffects of millimeter waves and the projected increase in use of this part of the spectrum, more studies on possible health and safety implications of millimeter waves are surely needed. There have already been too many fishing expeditions, however; high-quality research is needed, and also continued monitoring of the scientific literature by health agencies.

Because an individual's greatest exposure to RF energy is when he or she uses a cell phone, a concerned individual could simply refrain from using one.